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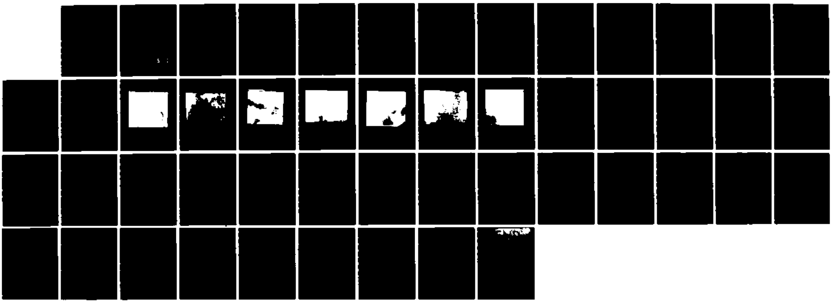

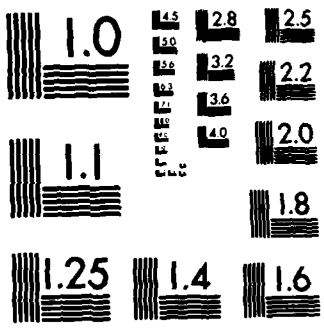

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NRL Memorandum Report 5428

AD-A146 780

Conditions Governing the Formation of Stratocumulus Clouds Over the Western Atlantic During Cold Air Outbreaks

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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

Extensive stratocumulus (Sc) clouds form frequently in the winter months over the western North Atlantic Ocean during episodes of cold air advection off the continent. During a four month study period (November 1981 through February 1982), 25 separate episodes resulted in varying extents and amounts of maritime cloud cover during 36 days, or 30% of the time during the study period. An examination of satellite imagery and surface analysis charts shows that these offshore Sc formations occur primarily following the passage of a cold front offshore, or in the southwest quadrant of a passing cyclone, or with the development of a high pressure ridge over the Atlantic coastal states. Data from four buoys between Cape Hatteras and Maine were used to look for thresholds in air-sea temperature difference (ΔT) and surface windspeed for the initiation and maintenance of these Sc formations. For locations from 25 to 200 miles (40 to 300km) east of Cape Hatteras, thresholds of 5°C and 5 m/s at a given at-sea location seem to be a good predictor for the existence of Sc overhead. The reliability of this rule decreases rapidly within 50 miles (80km) of the shoreline where the fetch may be inadequate. For locations 150 miles (240km) or so east of Cape Cod and in the Gulf of Maine,

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19. ABSTRACT (Continued)

these rules break down and the air sea temperature difference and windspeed do not appear to have any useful predictor capability. Other findings are: Sc from cold air advection forms only under conditions of rising barometric pressure, and the ΔT under open celled clouds far out to sea is no different, on the average, from the ΔT under closed cell Sc closer to shore.

CONTENTS

PREFACE

This report was sponsored in part by the Marine Meteorology program at the Office of Naval Research. The collaboration among the authors for this study has been fostered by the recent establishment of the NAVAIR Research Chair in Meteorology at the U.S. Naval Academy (USNA). One of the authors (RKJ) was the first occupant of the Research Chair in 1980-81. Acknowledgement is also due to CDR John Simpson, Chairman of the USNA Oceanography Department during this study, for encouraging this collaborative work between his faculty, students, and outside researchers. LCDR Art Trapp, officer in charge of the Naval Oceanography Command Detachment (NOCD) at the National Climatic Data Center (NCDC) in Asheville, North Carolina, and the NOCD Technical Advisor, Mr. Brian Wallace, are acknowledged for their help and cooperation in supplying us with the buoy data.

CONDITIONS GOVERNING THE FORMATION OF STRATOCUMULUS CLOUDS OVER THE WESTERN ATLANTIC DURING COLD AIR OUTBREAKS

INTRODUCTION

Extensive stratocumulus (Sc) formations over the western Atlantic are very common in late fall, winter, and early spring. These particular clouds are formed when cold, continental polar (cP) air is advected over the relatively warmer waters of the Atlantic Ocean. The air often becomes unstable due to the warming from below, and stratocumulus clouds form over the ocean waters. The phenomenon is basically the "lake effect" situation that is well known in the Great Lakes Region of the United States, except that the over-water fetch is much longer at sea.

These horizontally extensive cloud formations (Figures 1, 3, 5, 7) are of interest because they can affect naval air operations in the area. For example, the cloud base height reportedly decreases with distance seaward and aircraft carriers have been known to move toward shore in some cases in order to obtain adequate ceilings for aircraft operations. High ceilings allow the carriers to remain radar-silent and thereby to avoid identifying their presence and position. However, the freezing level height decreases shoreward and therefore the possibility of aircraft icing conditions may partially offset the advantages of a higher ceiling. As another example, these widespread cloud formations may also interfere with future, optical (laser) communication links such as between satellite and submarine.

On the other hand, these cloud formations can be helpful when cloud cover is desired to shield surface operations from view by other aircraft or spy satellites.

In any case, the ability to forecast the onset and location of these uniquely maritime cloud formations would be an asset to any of these naval operations, as well of scientific interest, in general.

These clouds form offshore in cloudless, cold air advecting off the continent and therefore the forecaster's job is not as easy as tracking a pre-existing cloud system. The clouds form along a line that is generally conformal to the coast and they spread seaward as a continuous, expanding sheet following the cold air trajectory. Sometimes the areas off the entire Atlantic seaboard and the Gulf of Mexico are affected and at other times only areas from the middle Atlantic states northward are involved. In some cases the line of formation lies very close to shore and in other cases it lies far out to sea.

Considering the naval interests mentioned above, the following aspects of these offshore cloud formations are the principal items to be investigated.

a. The factors and variables controlling the onset of cloud formation and the distance from shore that cloud formation begins.

b. The conditions governing the conversion of closed cell clouds to open cell clouds.

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c. The behavior of the freezing level, cloud base height (ceilings), and mixing layer depth with time and distance seaward or downwind of the shoreline.

d. The geographical areas affected.

BACKGROUND

General Conditions for Offshore Sc Formations

Stratocumulus formations that are generated directly over the water of the western Atlantic ocean are formed during the movement of cold, polar air eastward off the continent. A comparison of the satellite imagery with the surface analysis maps for each occasion reveals that all major Sc formations are associated with just three basic synoptic situations. These are: (a) a wave cyclone along the Atlantic coast, usually accompanied by a high pressure system over the eastern third of the United States (Figs. 1-2), (b) a cyclonic system moving through Quebec to Newfoundland, and almost always complemented by a high pressure system centered over the southeastern United States (Figs. 3-4), and (c) a lone high pressure system centered over the eastern third of the United States (Figs. 5-6). These weather systems are all ideal for the advection of cold air over the relatively warm waters of the western Atlantic and the Gulf Stream [1]. The result (during the winter months) is often a large air-sea temperature difference, ΔT, which is thought to be the primary mechanism for producing convection and the resultant generation of Sc clouds.

In synoptic situation (a), the advection of cold air offshore will occur mainly in the southwestern quadrant of the cyclone. These low pressure systems typically migrate northeastward along shore from the middle Atlantic states into New England and the Canadian maritime provinces, or they may move directly offshore somewhere between Cape Hatteras, North Carolina, and Nova Scotia. These cyclones are often followed by an anticyclone or a developing ridge of high pressure over the middle Atlantic states, as is shown in Figure 2. This tandem arrangement of a low pressure system to the northeast and a high pressure system to the southwest of the coast is very effective in advecting cold air offshore between the two. The stronger circulation is usually associated with the cyclonic system and therefore the Sc is usually better devloped nearer the cyclone. In this case the Sc formation will show cyclonic curvature as seen in the satellite imagery of Figure 1. Anticyclonic curvature may also be seen nearer the high pressure system if the circulation around it is sufficiently strong. A long, arcing cold front may extend southward from the cyclonic center and bring cold air and Sc production as far south as Florida. Even the Gulf of Mexico may be affected if the anticyclone is centered well inland, as is the case in Figures 1 and 2.

In synoptic situation (b), the advection of cold air offshore will occur mainly in the southeastern quadrant of the inland low pressure system

moving from Quebec northeastward or eastward into Newfoundland. Almost always there is a high pressure system located simultaneously over the southeastern United States, as is shown in Figure 4. The anticyclonic circulation complements that of the low pressure system to the north and thereby aids in the advection of cold air offshore. Usually, Sc production is limited to the waters north of the middle Atlantic states, as is seen in Figure 3.

Synoptic situation (c) is similar to (a) except that any low pressure system which may have existed to the northeast has by now moved so far away that it's influence has ceased and the offshore circulation is now due entirely to the anticyclone. When effective, these high pressure systems are usually centered over the middle Atlantic states. Occasionally the center will range as far north as Quebec, with a high pressure ridge extending down into the middle Atlantic or southeastern states. More rarely the high pressure system will be a massive one centered over the central United States and which is associated with a severe outbreak of arctic air from central Canada, as on January 7-11, 1982.

Closed and Open Cellular Structure

Satellite images reveal that Sc formed by cold air advection over the western Atlantic commonly consists of uniform overcast or tightly packed closed cells or cloud streets near shore, transitioning to open cells out to sea. The formation of open and closed cells is dependent on the depth of convection. Open cells are thought to be formed by relatively intense heating from below [2] (large air-sea ΔT) and are composed of cloudless, or less cloudy, centers surrounded by a ring of U-shaped clouds. Where the clouds are predominantly cumulus congestus and cumulonimbus the air-sea ΔT is thought to be very large. The open cellular clouds are capped by a subsidence inversion near the coast and by dry air entrainment further downstream [2]. Contrary to these ideas, however, data from the present study show that the ΔT below the open cell areas is no greater, on the average, than below closed cell Sc. There is also no evidence in the satellite imagery that the Gulf Stream necessarily forces a transition from closed to open cell convection.

Closed cells form where the depth of convection is less than that which forms open cells. Closed cells can be distinguished by their polygonal shape and clear, or less cloudy, cloud walls. Closed cells are primarily stratocumulus and are capped by a subsidence inversion [2].

Cold air advection and the associated Sc over the western Atlantic is often characterized by cyclonic curvature. This is revealed by the "cloud streets" that form behind a cold front (Figure 1). The clouds are aligned parallel to the wind and the "streets" are easily seen in the closed cell pattern. The streets are formed when a strong wind shear exists and the cellular patterns breakdown into longitudinal bands. Tsuchiya and Fujita [3] showed the effects of wind shear on cellular clouds off the Pacific coast of western Japan. They found that the higher wind shear values broke the convective cells into bands and the lower shear values had little or no effect on the cellular clouds.

The distance between the shoreline and the edge of Sc formation is referred to as the cloud free distance (CFD). The CFD appears to be related to the topography of the coastline as can be seen when the winds are nearly perpendicular to the coastline. Figures 3 and 7 illustrates how the edge of formation (EOF) often conforms to the shape of the coastline. Holroyd [4] suggests that lake effect cloud bands form first where the greatest fetch exists. His analysis showed that cloud bands formed downwind from the center axis of the lakes and bays. Applying Holroyd's analysis to Figure 7 one could assume that inlets and bays along the coastline assist the development of Sc formations. By increasing the fetch, the bays cause the clouds to form locally closer to the general outline of the coast.

Prediction of the Occurrence of Offshore Sc Formation

When cold air moves over warm water, the resulting upward fluxes of heat and moisture often produce Sc clouds, enhanced growth of the convective boundary layer and the warming and moistening of that layer [5]. To the authors' knowledge, no convenient method has been published for predicting the formation of Sc over the western Atlantic.

Only a few studies have been made on the cold air advection process and the resulting Sc over the North Atlantic. Emmons [6] studied the vertical temperature and humidity distributions over the Atlantic during cold air advection. The Army Air Force (AAF) Weather Service [7] found that surface heating of a polar air mass was the most dominant process which modified the air mass. The U.S. Air Force Air Weather Service[8] provides valuable satellite analysis on open and closed Sc that form as a result of cold air advection.

There have been several studies on stratocumulus formation over the Great Lakes. Lake effect clouds form in a manner that is similar to stratocumulus over the western Atlantic. Holroyd [4] found a strong correlation between the formation of lake effect clouds and the difference in temperature between the lake surface and the 850mb level. A lake-effect intensity forecast method resulted from another study on snowfall systems induced by Lake Ontario. Dewey [9] found the 850mb-lake surface temperature difference to be the most important factor in his predictor. The surface wind fetch and velocity were also important factors. Other factors in Dewey's predictor include: the percentage of ice cover on the lake, the vapor pressure gradient at 2.5 meters over the lake, wind fetch at 850mb over the lake and the average relative humidity from the surface to 500mb. If this forecast method were applied to stratocumulus over the western Atlantic, three of the predictors would drop out (ice, fetch, fetch at 850mb), since very little ice forms on the western Atlantic Ocean and the fetch is unlimited. This leaves the 850mb air-water temperature difference, the wind speed, the vapor pressure gradient at 2.5 meters above the surface and the average relative humidity as the important factors in predicting cloud formation according to Dewey's method.

There has been a recent study on the mean latent and sensible heating over the western Atlantic. Chou and Atlas [5] found the air-sea temperature difference, surface relative humidity and the cloud free distance (CFD) to be related to the sensible heating of a polar air mass as it moves over the ocean. The air-sea temperature difference, again, appeared to be the most important factor.

Only a few studies have been done on Sc clouds themselves over the western Atlantic. The major obstacle in studying these clouds is the difficulty in obtaining meteorological data. Several buoys in the Atlantic Ocean transmit both air and water temperatures to recording stations ashore. These data are readily available from the National Climatic Data Center in Asheville, North Carolina. Because the air-sea ΔT are available, and several studies have related these ΔTs to the formation of lake-effect clouds, correlating the air-sea ΔT to the formation of Sc over the western Atlantic was chosen as the hypothesis of this study.

Some observers in the U.S. Navy use the following unpublished "rule of thumb" to predict the potential for Sc formations in the western Atlantic:

Using air-sea ΔT as a guide: (see footnote)

1. if $\Delta T < 5^{o}C$: expect no clouds,
2. if $\Delta T = 5^{o}$ to 8^{o}: anticipate some cloud formation,
3. if $\Delta T > 8^{o}C$: expect clouds to form.

This guide was not supported by examples and does not describe the type (closed cell or open cell), the extent or the distance offshore that the clouds form.

In studies of offshore Sc formation during the Air Mass Transformation Experiment (AMTEX) near Japan in 1975, Agee and Sheu [10] report that, at a minimum, a ΔT of $5^{o}C$ <u>and</u> a windspeed of 5 m/s are necessary for offshore Sc to form. Both of these threshold conditions will be tested in this report for Sc formation over the western North Atlantic.

RESEARCH METHOD

A method of predicting the formation of Sc clouds is the goal of this study.

Four winter months (Nov. 1981 through Feb. 1982) were chosen as the initial study period since the Sc of interest form as a result of cold air advection.

Note: To avoid confusion in dealing with relative magnitudes of ΔT, the absolute magnitude $|\Delta T|$ will be used when specifying numerical values. In all cases of interest in this study, $|\Delta T|$ is the temperature by which the near surface air is <u>colder</u> than the sea surface.

Data available for the study included:

1. Four data buoys from which air-sea ΔT were derived at four offshore locations (Figure 8). There were several periods for each buoy where the temperature data were missing.

2. 1200 GMT daily weather analysis charts were used to determine the surface weather systems and wind directions when Sc were observed over the western Atlantic.

3. Satellite images (infrared and visual) were used to identify the Sc formations. Images were usually available every six hours.

The objective is to predict the formation of extensive Sc resulting from cold air advection. The hypothesis is that the Sc will form as a result of the air-sea ΔT regardless of the absolute air temperature or sea surface temperature.

The research methodology consisted of analyzing each of the satellite images where Sc formations were observed, and comparing the daily surface weather charts and the air-sea ΔTs from the four selected buoys. Each of 25 Sc formation cases were studied in the following manner:

1. Analyze data from individual buoys where Sc formed over, or upwind, of the buoy.

2. Observe and record the time and the air-sea ΔT when the Sc began to form.

3. Observe and record the time and the air-sea ΔT where the Sc existed in their greatest horizontal extent.

4. Observe and record the approximate time and air-sea ΔT for Sc dissipation.

5. Note the synoptic conditions when the clouds formed.

6. Note the downwind distance from the coast that Sc formed.

7. Note the horizontal distance of the solid deck of Sc.

8. Note the direction of the wind in relation to the coast.

A comparison of the air-sea ΔTs at the buoy locations with the presence or absence of Sc clouds overhead was used to look for an approximate ΔT requirement for the formation and continued existence of Sc clouds due to cold air advection.

RESULTS

Twenty five independent cases of Sc formation were identified during the four month period of interest. Table 1 lists the relevant data that were available from four of the moored buoys that are maintained in the nearby Atlantic by the NOAA Data Buoy Office [11]. The buoy data were actually obtained from records archived at the National Climatic Data Center [NCDC] in Asheville, North Carolina. The buoys are numbered here according to the last digit of their identification code in the ship data records at NCDC. The positions of the buoys are shown in Fig. 8. The data are available more or less hourly throughout the study period, although there are occasional periods where data from one buoy or another are missing. Table 1 contains representative data selected periodically throughout each episode to coincide with imagery from the GOES-East weather satellite as available from the GOES tap and Unifax facsimile printer at the U.S. Naval Academy.

The values of ΔT and windspeed are plotted in Fig. 9 for each buoy. An inspection of Fig. 9 yields the following observations:

Threshold Values of ΔT and Windspeed.

Buoy 1, located 175 nmi east of Cape Hatteras was most often involved in these Sc formations. For Buoy 1, a threshold ΔT of $6^{\circ}C$ and a threshold windspeed of 10kt (5 m/s) are easily established from Fig. 9 as conditions for the existence of cold air induced clouds overhead. Cloudless skies never existed over buoy 1 when the ΔT at that location exceeded $6^{\circ}C$. There were only two instances where clouds resulting from these cold air outbreaks existed over buoy 1 while the ΔT was slightly less than 6°.

Clouds were also present over buoy 1 in three instances when windspeeds were less than 10kt, but the probability of cloudless skies appears to increase rapidly for windspeeds below 10kt. In one of these three cases the Sc formation was in the dissipating stage and the shoreward remnants of the cloud formation had receded out to the vicinity of buoy 1 as the system weakened.

For buoy 6, located only 20 nmi offshore from Virginia Beach, Virginia, these threshold values are less reliable. The data in Fig. 9 suggest that better prediction of Sc over buoy 6 is obtained if the windspeed threshold is increased to about 20 kt (10 m/s). Except for cases where the prevailing wind is from the north, and therefore a longer fetch is available, the thresholds apply only to the likelihood that the leading edge of the Sc formation will occur as close to shore as the position of buoy 6.

Relatively fewer data points were available for the two northernmost buoys, 3 and 5. There are two reasons for this. One is that the Gulf of Maine region is less favorably situated for the advection of cold air which is also free of clouds from the driving cyclonic disturbance or from adjacent weather systems. Also, air temperature data were more often missing from these buoys during the dates of interest.

From Fig. 9 it appears that thresholds of 5°C and 15kt (7.5 m/s) may apply to buoy 3, but the data are insufficient to conclude anything about buoy 5 except that cloudless skies can occur for ΔTs up to 7°C.

Windspeeds and ΔTs Associated With Open Cell Clouds

Only buoy 1 was far enough offshore to be frequently in the region where the Sc formations change from closed cells, uniform overcast, or densely packed streets to the open cell type of formation. Examination of the data in Fig. 9 shows that open cells do not require a ΔT any larger than for closed cells. The limited amount of data does suggest that a windspeed of at least 15kt may be a necessary, but not sufficient condition for open cells to form.

Growth and Dissipation of Sc Formations

The sequential satellite imagery shows that these Sc formations appear as if they were being extruded behind passing cold fronts or cyclonic storms much like a swath of paint being laid down with a wide brush. The extended Sc formations then tend to persist in place until they gradually recede and dissipate, or until they are overrun and replaced by some invading cloud (and weather) system.

In about two-thirds of the episodes, an invading cloud system overran the Sc formations before they dissipated. The time required for an isolated Sc formation to dissipate ranges from one to four days, or more. In this study period, the average lifetime of all Sc formations was about 1 + 1/2 days, and none lasted more than 3 + 1/2 days before being overrun and replaced. The one episode lasting for 4 + 1/2 days from December 9th to 14th is actually an unusual double case. About two days after the original west-to-east development, a passing weather system re-oriented the flow to a north-to-south formation without completely obliterating it in the process.

The Sc developments occurred exclusively under conditions of rising barometric pressure in the vicinity. Incidentally, in only one case was the barometric pressure less than 1000mb at the onset of Sc development. Usually the pressure continued to increase up until dissipation or replacement occurred. There does not seem to be any particular pressure level associated with dissipation, however. Pressures which existed at the time of dissipation ranged from 1010mb to 1036mb. Barometric pressure was not related to the intensity or quality of the Sc formation either. Weakly developed cases as well as strong, extensive formations occured with initial pressures anywhere in the 1000-1032mb range. The only barometric rule of thumb that may be useful as a necessary, but not sufficient requirement for the onset of Sc development is derived from the observations stated at the beginning of this paragraph. That is, Sc initiation from cold air advection occurs only with a rising barometer.

Dissipation occurs in either of two modes. The most easily recognizable mode is when the upwind edge of formation (EOF) recedes farther out to sea and leaves cloudless skies extending back to the shoreline. This clearing occurs as either the ΔT or the windspeed, or both at that location

drop below their threshold values. Often a general weakening or thinning of the receding Sc system occurs as well. In the other mode of dissipation, the Sc system just weakens in place and breaks up into scattered bloblike cloud remnants without leaving any streets, cellular features, or a recognizable EOF as are associated with an identifiable Sc formation. Visually, it is difficult to decide when the residual cloud system should no longer be considered a valid Sc formation. At some time during this decay the ΔT and/or windspeed drop to their threshold values, however, and this occurrence would be one logical way to define the end of the episode.

Recommendations for Future Study

The study revealed the problems in obtaining data to analyze the Sc. Buoy data are often incomplete and ship observations are too random to study a selected area of Sc formations. Since meteorological data over the ocean are so difficult to obtain, it would be advantageous to obtain measurable coastal data to predict the convective stability. These data include vorticity advection, the lifted index, the vertical velocity, surface wind speed and the relative humidity. A correlation of each of these parameters with the onset of Sc formation should reveal their relative importance on predicting Sc formations. Once the importance of these factors is investigated, a more precise model to predict these clouds should begin to take form.

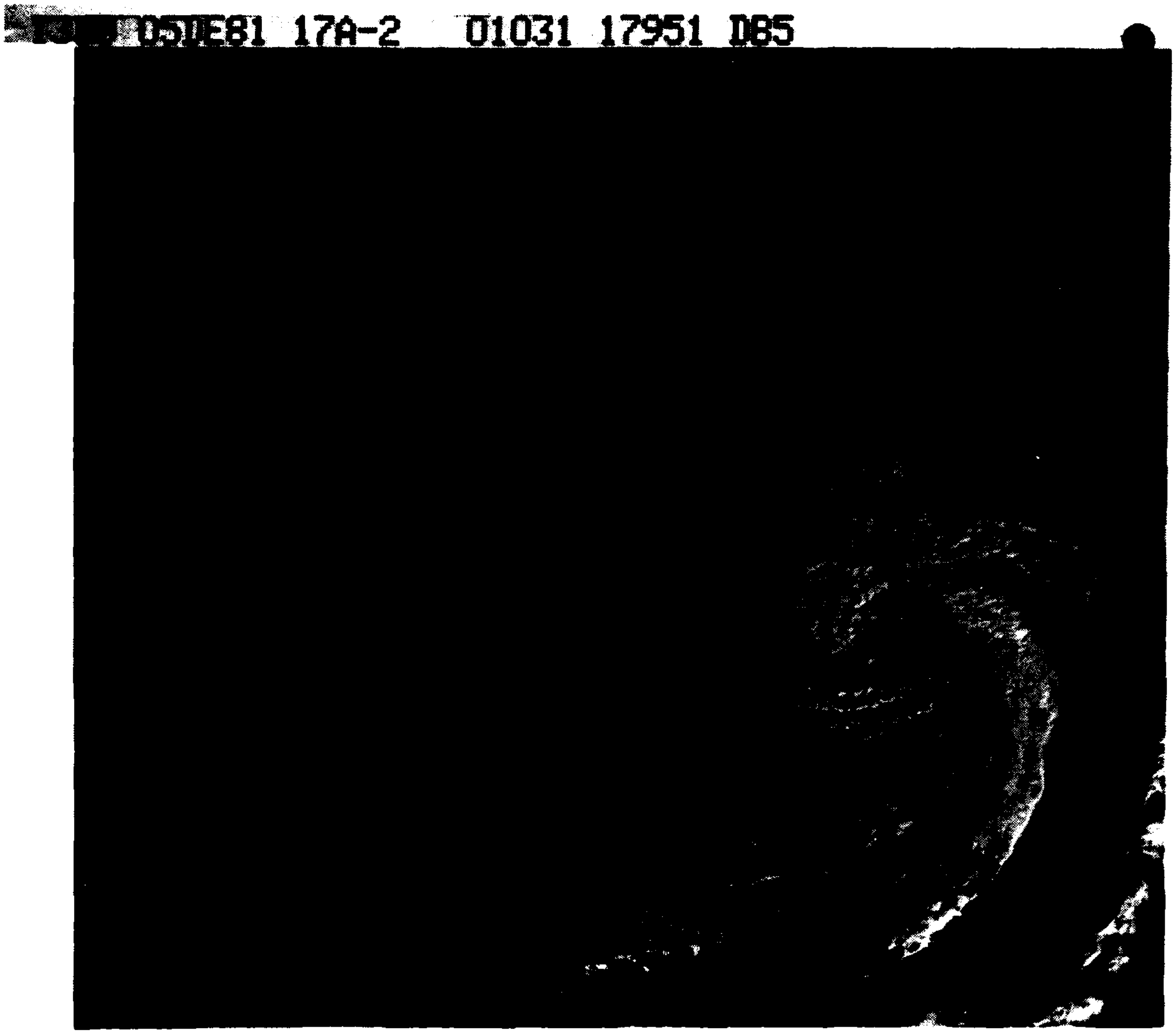

Figure 1. Stratocumulus (Sc) forming in the southwestern quadrant of a wave cyclone passing offshore. Offshore cold air advection is typically assisted by circulation around a high pressure system centered over the southeastern states (see Fig. 2). In the case shown here, Sc has even formed in the Gulf of Mexico as a result of cold air circulation around the anticyclone.

Figure 2. Surface weather map for the case shown in Fig. 1. This tandem cyclone-anticyclone system is typically responsible for about half of the Sc formation cases.

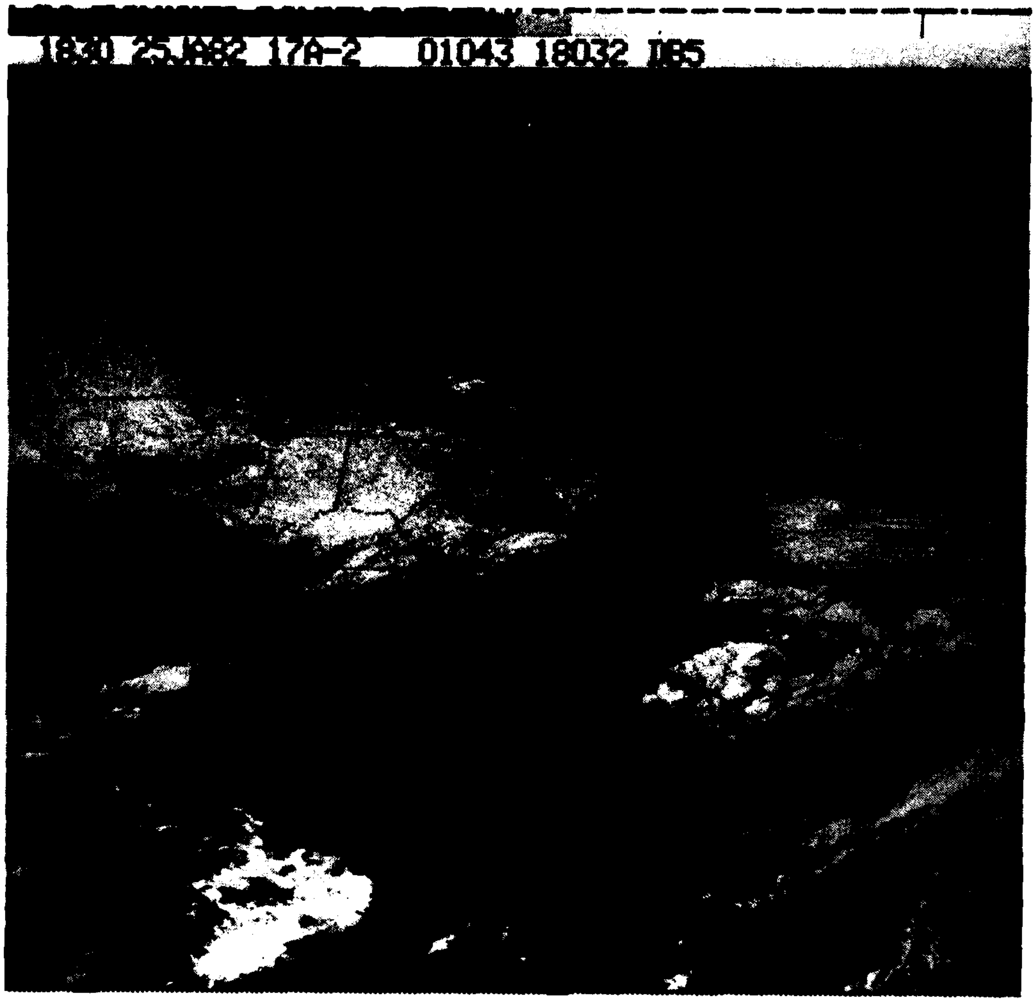

Figure 3. Stratocumulus formation north of Cape Hatteras due to cold air advection around a low pressure system centered between Quebec and Newfoundland, and south of Cape Hatteras due in part to cold air advection around a high centered over the southeastern states (see Fig. 4).

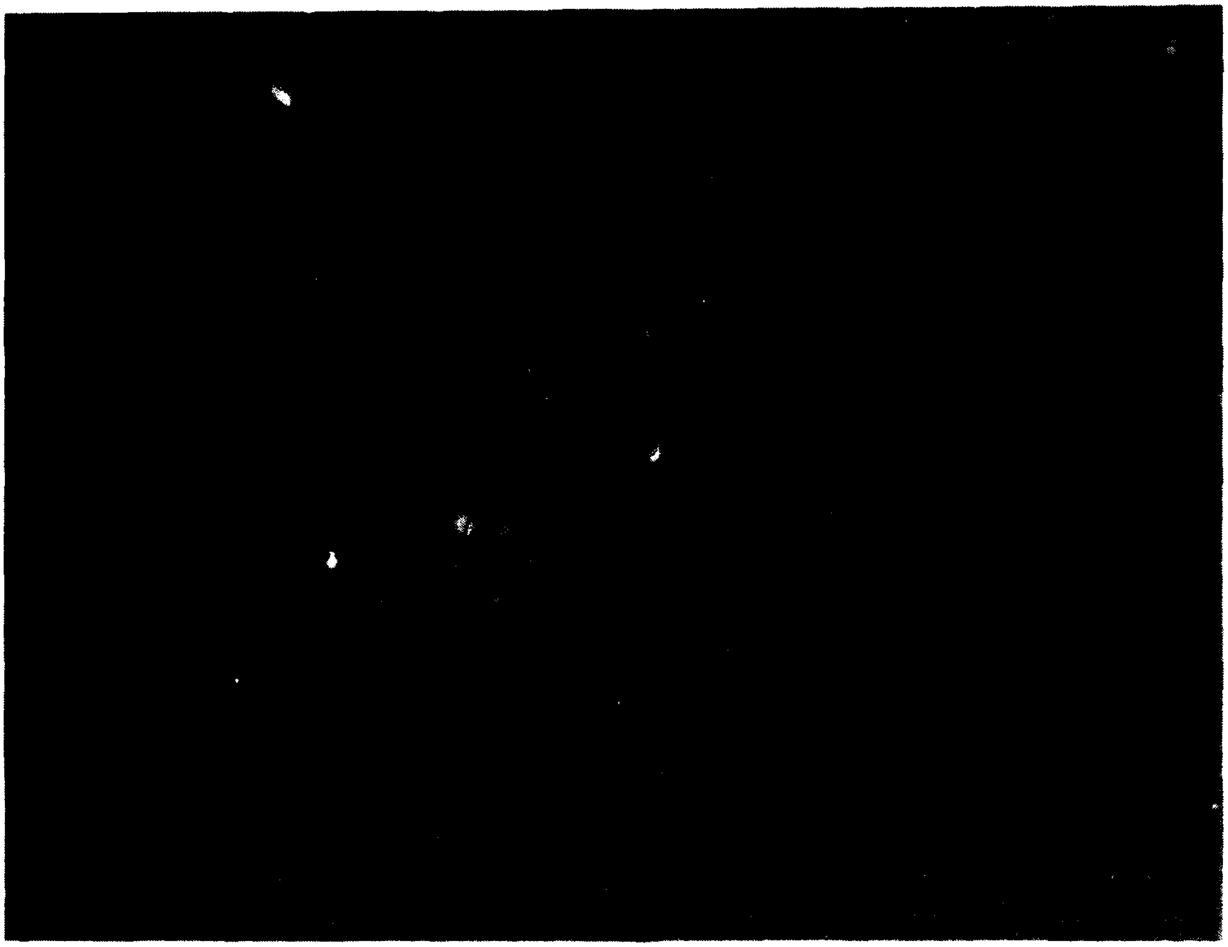

Figure 4. Surface weather map for the case shown in Fig. 3. This tandem cyclone-anticyclone arrangement is typically responsible for about 25% to 35% of the Sc formation cases.

Figure 5. Stratocumulus forming along tne entire Atlantic coast as a result of cold air advection around a large anticyclone centered over the middle Atlantic states (see Fig. 6). The cloud pattern far at sea shows some curvature toward a cyclonic center that has moved offshore well in advance of the high pressure system and is located near the lower right-hand edge of this frame.

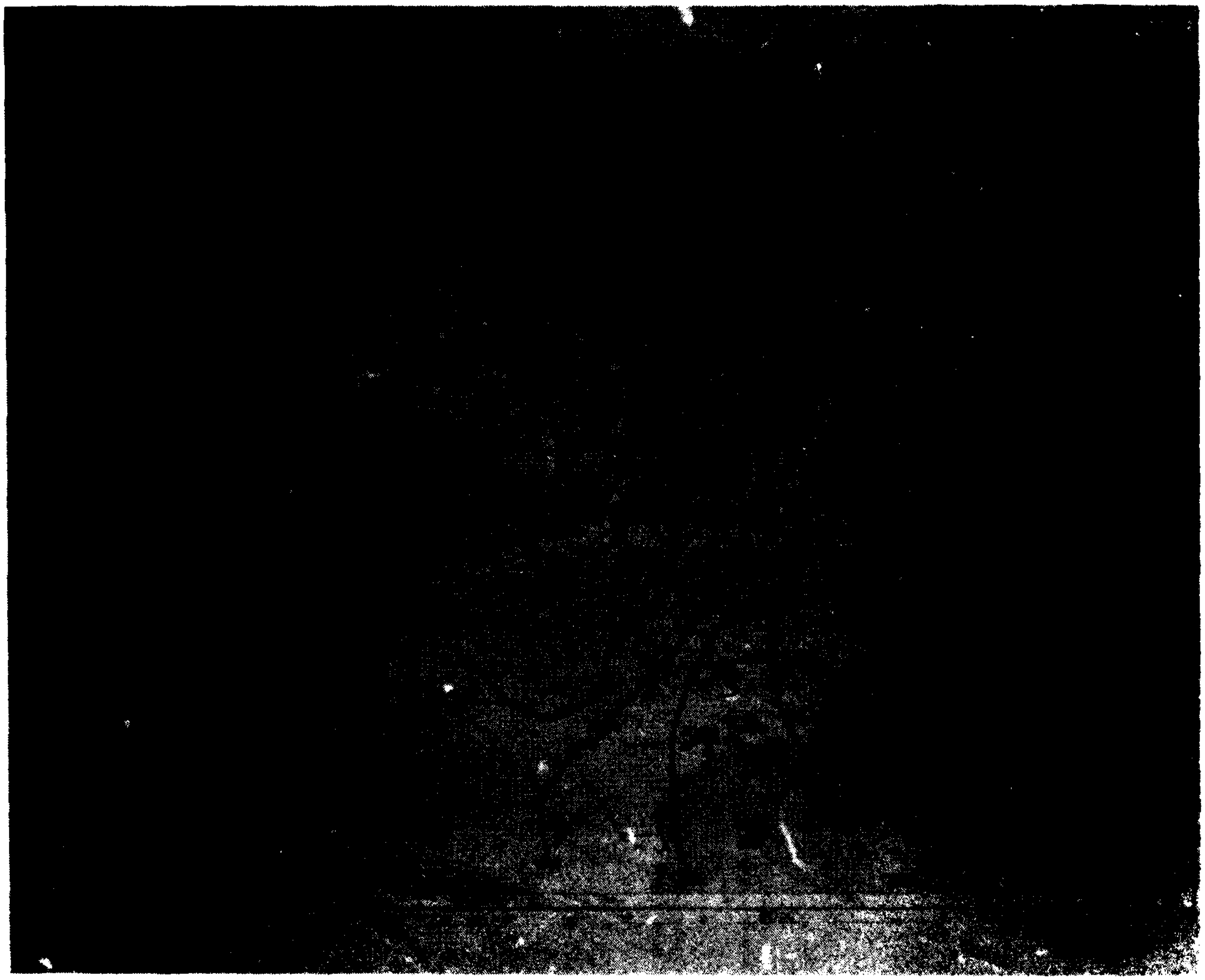

Figure 6. Surface weather map for the case shown in Fig. 5. These nearly isolated anticyclones are responsible for about 25% to 35% of the Sc formation cases.

Figure 7. An extensive stratocumulus formation due to cold air advection around a massive anticylone centered over the western Great Lakes and covering the entire eastern half of the United States. Note the extension of the cloud forming edge into Chesapeake Bay and Delaware Bay in this case.

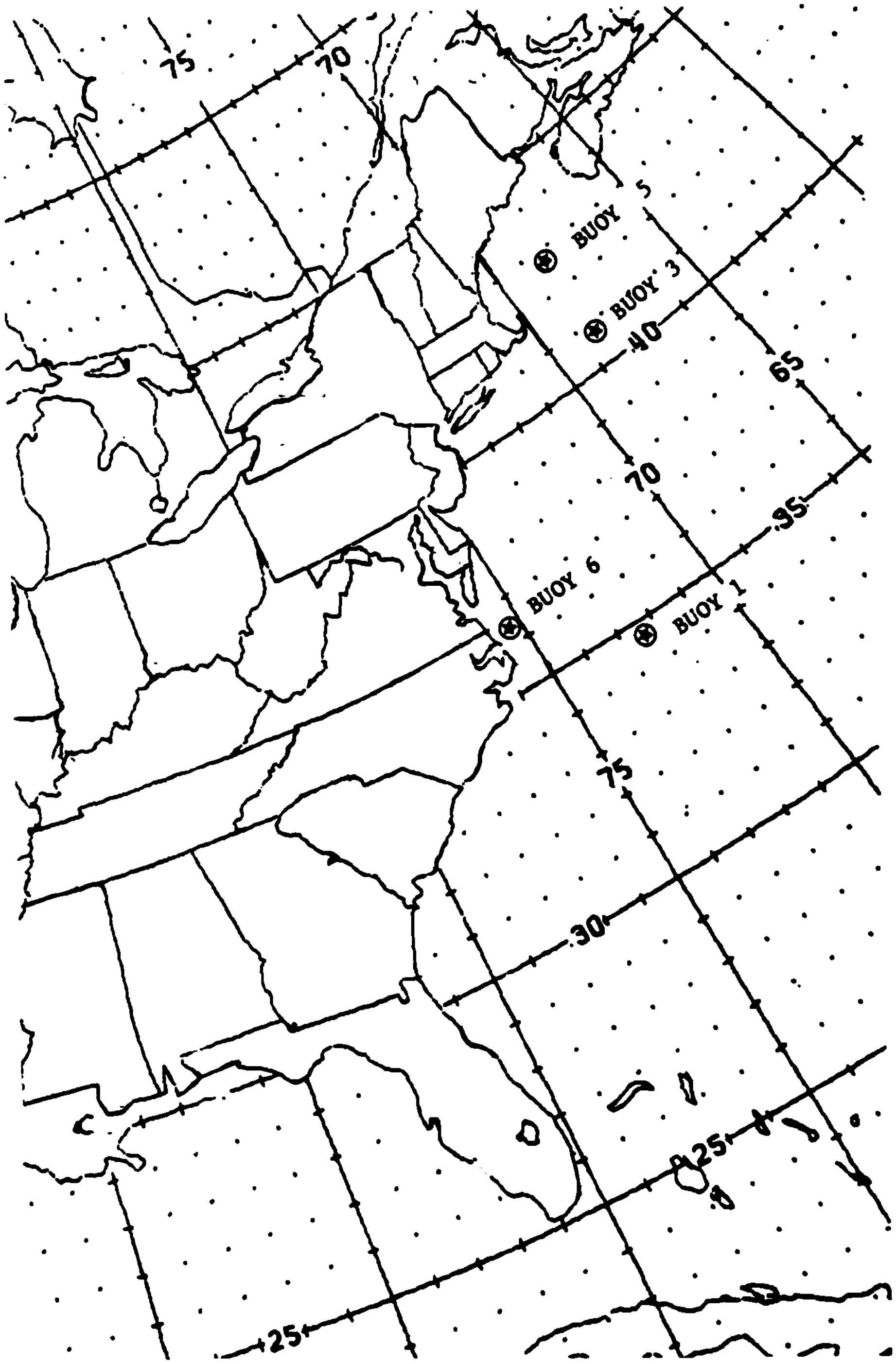

Figure 8. Location of the four data buoys used in this study.

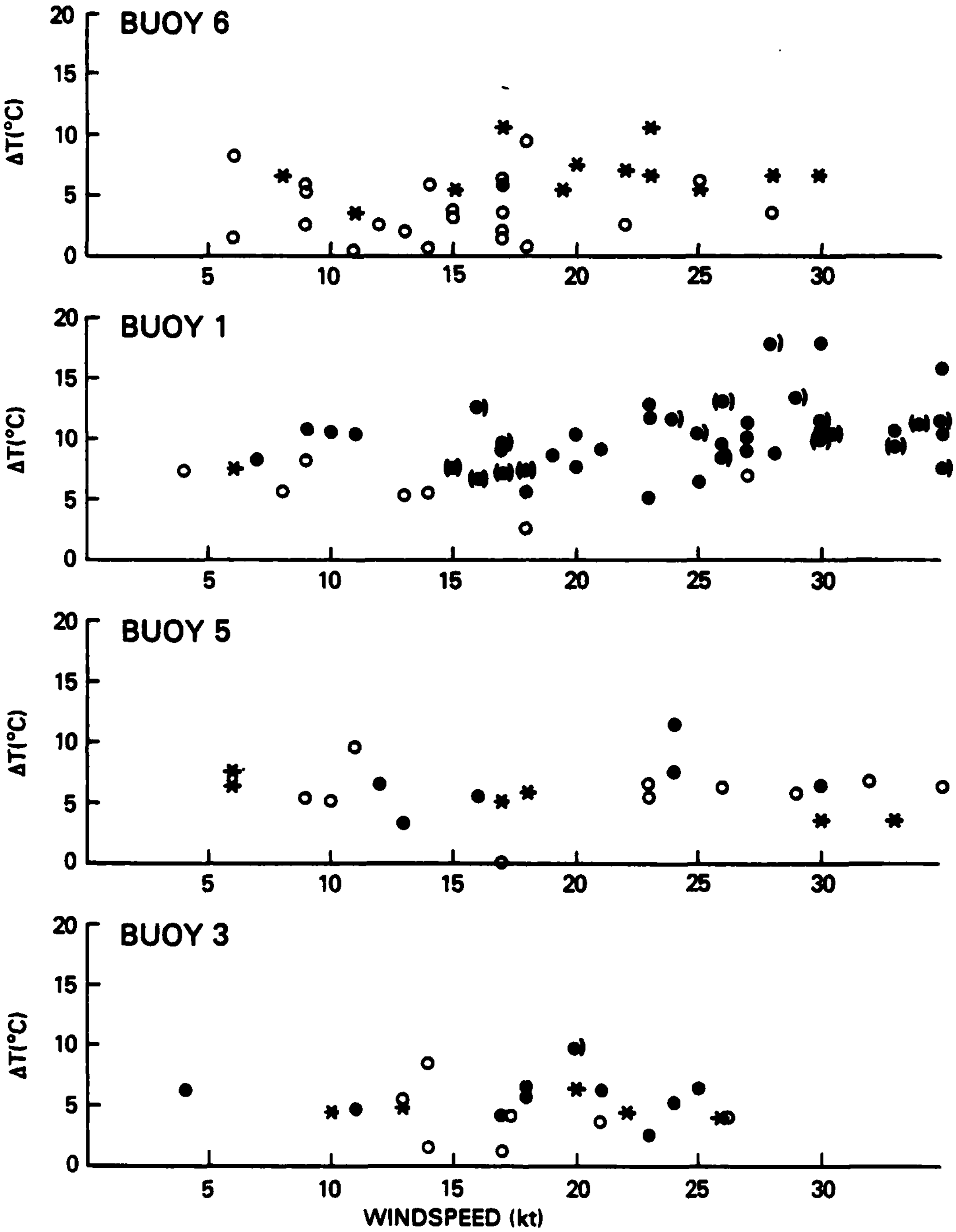

Figure 9. Scatterplots of the air-sea temperature difference, ΔT, vs. windspeed at each of the buoys during occurrences of offshore Sc formations. Cloud conditions over the buoy at the time of the measurements are indicated by the following symbols: o ---- clear sky, • ---- Sc, •) ---- transition from solid overcast, dense streets, or closed cells to open cells, (•) ---- open cell clouds, ϕ ---- scattered remnants, * ---- buoy at edge of cloud formation.

Table 1 — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

November 1981

BUOY NO. 1 (Ship code no. 41001)

Case No.	Date(1981)	Time(GMT)	Stage of Formation (Note a)	Cloud Conditions At Buoy	CFD Offshore (nmi) (Note b)	Distance Buoy to forming edge(nmi) (Note c)	-- Surface Conditions -- Baro.Press (mb)	Air Temp (°C) (Note d)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C) (Note e)	Quality of cloud Formation	Synoptic Driving situation (Note f)
2	18 Nov.	1300	B	Broken, Chaotic	150	+100	1007	+17.1	WNW	23	22.2	5.1	weak	A
	19 Nov.	0130	Rc	Coarse Streets	200	+ 75	1011	+16.1	WNW	18	22.1	5.5	weak	A
	19 Nov.	1530	Rc & D	Clear	500	-150	1016	+16.7	NNW	14	22.2	5.5	weak	A
	Duration of episode: 1 day.							Reason for demise: Dissipation						
3	21 Nov.	1000	B	Broken, overcast	50	+200	1007	+13.0	WNW	28	21.8	8.8	good	B
	22 Nov.	0130	C	Broken, overcast	50	+200	1012	+13.0	WNW	19	21.7	8.7	good	B
	22 Nov.	1930	D	Thin, broken	125	+150	1014	+12.5	W	17	21.9	9.4	weak	B
	23 Nov.	1500	D	Scattered remnants	?	?	1017	+13.9	WNW	9	21.9	8.0	weak	B
	Duration of episode: 1 1/2 days.							Reason for demise: Dissipation						
5	25 Nov.	1400	B	Transition to open cells	~50	+300	1007	+14.3	N	35	21.7	7.4	excellent	A
	25 Nov.	1930	C	Reclosed overcast	~50	+350	1011	+12.6	N	27	21.6	9.0	excellent	A
	27 Nov.	0130	Rc,D,Rp	Clear	550	-150	1021	+15.3	W	8	21.1	5.8	weak	A
	Duration of episode: 1 1/2 days							Reason for demise: Dissipation						

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

November 1981

BUOY NO. 3 (Ship code no. 44003)

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
1	08 Nov.	1000	B	Overcast	50	+100	1007	+6.6	WNW	18	12.5	5.9	fair	B
	08 Nov.	1930	Rc	-EOF	150	+ 25	1013	+7.6	NW	13	12.6	5.0	fair	B
	09 Nov.	0130	Rc & D	Clear	200	- 75	1018	+11.0	W	14	12.6	1.6	weak	B

Duration of episode: 1/2 days   Reason for demise: Dissipation

November 1981

BUOY NO. 5 (Ship code no. 44005)

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
1	08 Nov.	1930	B	Broken, overcast	75	+ 20	1011	+ 7.6	WNW	13	10.7	3.1	fair	B
	09 Nov.	0130	Rc & D	Clear	300	-150	1017	+10.5	SW	17	10.5	0	weak	B

Duration of episode: 1/2 day   Reason for demise: Dissipation

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
4	23 Nov.	1430	B	Overcast	40	+100	1012	+ 4.0	W	16	9.4	5.4	weak	B
	24 Nov.	1330	C	Dense thin streets	40	+100	1015	+ 2.7	W	12	9.3	6.6	weak	B

Duration of episode: 1 1/2 days   Reason for demise: Replacement

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

November 1981 BUOY NO. 6 (Ship code no. 44006)

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
1	07 Nov.	1930	B	Clear	40	- 10	1008	+11.4	W	15	15.1	3.7	fair	B
	08 Nov.	0130	Rc	Clear	125	-100	1012	+13.0	WNW	17	15.0	2.0	fair	B
	08 Nov.	1330	Rc & D	Clear	400	-375	1020	+12.1	WNW	12	14.5	2.4	weak	B
	Duration of episode: 1 day							Reason for demise: Dissipation						
2	18 Nov.	1300	B	Clear	150	-100	1007	+11.7	WNW	17	13.2	1.5	weak	A
	19 Nov.	1030	Rc	Clear	200	-175	1010	+13.6	WSW	7	13.1	---	weak	A
	Duration of episode: 1/2 day							Reason for demise: Recession & Dissipation						
3	21 Nov.	1000	B	Clear	75	- 50	1007	+ 7.0	W	25	13.0	6.0	good	B
	22 Nov.	0130	C	EOF	40	- 10	1013	+ 7.6	W	19	12.9	5.3	good	B
	22 Nov.	1930	C	EOF	25	~0	1016	+ 6.1	WNW	8	12.9	6.8	weak	B
	23 Nov.	1430	D	Clear	?	?	1020	+ 7.5	N	9	12.7	5.2	weak	B
	Duration of episode: 2 days							Reason for demise: Dissipation						
5	25 Nov.	0700	B	EOF	~30	~0	1009	+ 5.9	NNW	30	12.5	6.6	excellent	A
	25 Nov.	1930	C	EOF		0	1016	+ 5.1	NW	22	12.1	7.0	excellent	A

Sat. pix missing from 1930 on Nov. 25 till 0130 on Nov. 27. System is receding & being replaced near buoys 1 and 2 by new Wx system from west.

Duration of episode: 1/2 day Reason for demise: ---

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

December 1981

BUOY NO. 1

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
6	30 Nov.	1800	C	Transition C→O cells	100	+200	1019	+11.4	NNW	17	21.0	9.4	fair	B → C
	Duration of episode: ~1 day							Reason for demise: Replacement						
7	05 Dec.*	1000	B	Smudged open cells	~0	+200	1001	+11.4	WNW	33	20.9	9.5	good	A
	05 Dec.	1930	C	Open cells	?	~+150	1009	+10.8	NNW	30	20.8	10.0	good	A
	06 Dec.*	1000	C	Transition C→O cells	~50	+200	1012	+ 9.3	NW	37	20.6	11.3	good	A
	06 Dec.*	1530	C	Open cells	~50	+250	1012	+ 9.5	NW	34	20.6	11.1	good	A
	06 Dec.*	2030	Rc	Med. dense streets	175	+125	1012	+10.2	NW	35	20.5	10.3	fair	A
	Duration of episode: ---							Reason for demise: Recession & Dissipation						
	07 Dec.	1030	Rc	Clear	400	-100	1014	+13.5	WNW	27	20.4	6.9	---	---
	Duration of episode: 1 1/2 days							Reason for demise: Recession & dissipation						
8	09 Dec.*	1000	B	Transition C→O cells	~25	+225	1004	+11.7	WNW	26	20.2	8.5	good	A
	09 Dec.*	1930	C	Transition C→O cells	~50	+250	1004	+ 8.8	NW	30	20.1	11.3	good	A
	10 Dec.	1330	I	Transition C→O cells	~50	+300	1004	+ 6.4	NNW	29	19.7	13.3	excellent	A
	11 Dec.*	1530	C	Transition C→O cells	~30	+300	1007	+ 8.0	NW	24	.6	11.6	excellent	A
	12 Dec.	1330	C	Solid overcast	~70	+275	1015	+10.1	NW	21	19.6	9.5	fair	A

Cloud system being modified on No. and So. by passing WX system. Wind has changed to No. and cloud system orientation is now N to S.

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

December 1981 BUOY NO. 1 (Continued)

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	-- Surface Conditions -- Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
	13 Dec.	1530	C	Open cells	~25	+350	1023	+12.0	N	15	19.7	7.7	weak	C
	14 Dec.	0130	EOF	Clear	~300	~0	1026	+12.2	NNW	6	19.5	7.3	weak	C
	Duration of episode: 4 1/2 days							Reason for demise: Dissipation						
10	16 Dec.*	1930	C	Dense thin streets	~50	+175	1020	+11.3	WNW	20	19.1	7.8	good	A
	17 Dec.*	0130	D	Broken	200	+100	1024	+11.0	NW	7	19.1	8.1	weak	A
	17 Dec.	1330	D	Remnants	200	+100	1024	+12.0	W	4	19.1	7.1	weak	A
	Duration of episode: 1 day							Reason for demise: Dissipation						
11	19 Dec.	1930	B	Overcast	~25	+300	1016	+ 6.0	NNW	23	18.9	12.9	excellent	A
	20 Dec.*	1330	C	Transition C -O cells	~50	+175	1022	+ 6.4	WNW	16	18.7	12.3	excellent	A
	21 Dec.	1330	Rc	Lateral EOF	175	+150	1027	+ 7.7	NNW	9	18.6	10.9	good	A - C
	Duration of episode: 2 days							Reason for demise: Dissipation & replacement						
12	30 Dec.	1530	B	Open cells	50	+300	1027	+11.5	NNE	18	18.7	7.2	weak	A
	31 Dec.	0130	Rc & D	Wide weak open cells	~400	~+ 50	1030	+11.7	ENE	17	18.6	7.0	weak	A
	Duration of episode: 1/2 day							Reason for demise: Dissipation & replacement						

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

December 1981

BUOY NO. 3

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
6	30 Nov.	1800	C	Dense thin streets	100	+100	1012	+ 4.0	NNW	17	10.6	6.6	good	B
	01 Dec.	1430	Rp	Thin streets	?	+ ?	1021	+ 4.1	N	4	10.3	6.2	weak	B - C
	Duration of episode: 2 days						Reason for demise: Replacement							
9	13 Dec.	0130	B	Solid overcast	-75	+150	1016	+ 4.5	N	17	8.5	4.0	fair	C
	13 Dec.	1530	C	Thin sheet	150	+ 50	1021	+ 3.8	NNW	11	8.7	4.9	good	C
	13 Dec.	1930	D	EOF	200	~0	1022	+ 3.9	NNW	10	8.5	4.6	fair	C
	Duration of episode: 1 day						Reason for demise: Dissipation							
10	17 Dec.	0130	B	Broken	?	?	1014	+ 4.3	WNW	25	7.9	3.6	weak	A
	Uncertain condition; clouds may be higher and connected to low pressure center.													
	17 Dec.	1500	Rp	EOF	150	~0	1019	+ 3.5	WNW	22	8.2	4.7	weak	A
	Duration of episode: 1/2 day						Reason for demise: Replacement							
11	19 Dec.	1930	B	Lateral EOF cleft	0	+125	1009	+ 0.7	WNW	20	7.6	6.9	good	A
	Buoy is on edge of cloud free protrusion downwind (E) of Cape Cod.													

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

December 1981 BUOY NO. 3 (Continued)

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Surface Conditions: Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
	20 Dec.	1330	C	Transition C→O cells	0	+125	1016	- 2.2	WNW	20	7.6	9.8	excellent	A
	21 Dec.	1330	Rc	Clear	150	- 20	1022	- 1.0	WNW	14	7.4	8.4	good	A - C

Buoy is in long, cloud free "shadow" of Cape Cod.

Duration of episode: 2 days Reason for demise: Dissipation & replacement

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
12	30 Dec.	0130	B	Broken	150	+ 50	1015	+ 4.4	NW	23	7.0	2.6	weak	A
	30 Dec.	1530	Rc	Very thin	150	+ 50	1024	+ 1.0	NNW	25	7.2	6.2	weak	A
	31 Dec.	0130	Rc & D	Clear	350	-200	1029	+ 2.8	NNW	17	6.8	4.0	weak	A

System recedes and dissipates, but then regenerates for buoys 0 and 3 when high moves over New England?

Duration of episode: 1 day Reason for demise: Dissipation & replacement

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
	31 Dec.	1030	Ad	Back edge of clouds	?	?	1031	+ 2.3	N	12	6.9	4.6	weak	A
	31 Dec.	1930	C	Back edge	?	?	1032	+ 2.6	N	4	6.9	4.3	weak	A

Duration of episode: 1 day Reason for demise: Replacement

Table 1 (Cont'd) — Surface data and cloud conditions at each fo the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

December 1981

BUOY NO. 5

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	-- Surface Conditions -- Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
6	30 Nov.	1800	C	Clear	130	- 60	1012	+(2.3)	NNW	23	8.8	6.5	good	B
	01 Dec.	1430	Rp	Thin streets	?	+ ?	1020	+ 1.3	NNE	6	8.6	7.3	weakening	B → C
	Duration of episode: ~ 2 days						Reason for demise: Replacement							
9	13 Dec.	0130	B	EOF	~75	~0	1017	+ 3.0	N	17	8.0	5.0	fair	C
	13 Dec.	1530	C	Clear	100	25	1021	+ 2.7	NNW	9	7.9	5.2	good	C
	13 Dec.	1930	D	Clear	200	-150	1021	+ 2.9	NW	10	8.0	5.1	fair	C
	Duration of episode: 1 day						Reason for demise: Dissipation							
10	17 Dec.	0130	B	EOF	75	~0	1010	+ 4.5	W	33	8.1	3.6	weak	A
	Uncertain condition. Clouds may be higher and connected to low pressure center.													
	17 Dec.	1500	Rp	Clear	200	- 75	1016	+ 2.1	W	29	8.0	5.9	weak	A
	Duration of episode: 1/2 day						Reason for demise: Replacement							
11	19 Dec.	1930	B	Dense thin streets	10	+125	1006	- 0.3	W	24	7.8	7.5	excellent	A

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

December 1981

BUOY NO. 5 (Continued)

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Surface Conditions: Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
	20 Dec.	1330	C	Overcast	20	+100	1013	- 3.9	W	24	7.7	11.6	excellent	A
	21 Dec.	1330	Rc	Clear	100	- 10	1021	- 2.2	NW	11	7.5	9.7	good	A - C

Duration of episode: 2 days — Reason for demise: Dissipation & replacement

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Surface Conditions: Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
12	30 Dec.	0130	B	EOF	75	~0	1013	+ 3.8	NW	30	7.4	3.6	good	A
	30 Dec.	1530	Rc	Clear	125	- 75	1024	+ 1.1	NNW	26	7.2	6.1	good	A
	31 Dec.	0130	D & Rp	Clear	350	-300	1028	+ 1.7	NW	23	7.1	5.4	weak	A

System recedes and dissipates out then regenerates for buoys 0 and 3 when next WX system encroaches.

Duration of episode: 1 day — Reason for demise: Dissipation

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Surface Conditions: Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
	31 Dec.	1030	Ad	EOF	75	~0	1032	+ 1.1	NNW	18	7.0	5.9	weak	A
	31 Dec.	1930	C	EOF	75	~0	1031	+ 0.6	NNE	6	6.9	6.3	weak	A

Duration of episode: 1 day — Reason for demise: Replacement

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

December 1981

BUOY NO. 6

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	-- Surface Conditions -- Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
6	30 Nov.	1800	Rp	~Clear	100	- 75	1021	+ 5.6	NNW	14	11.5	5.9	good	B - C
	Duration of episode: ~1 day						Reason for demise: Replacement							
7	06 Dec.*	1000	B	EOF	~25	0	1016	+ 4.3	WNW	28	11.0	6.7	fair	A
	06 Dec.*	1530	C	EOF	25	0	1016	+ 4.4	W	28	10.9	6.5	good	A
	06 Dec.*	2030	Rc	Clear	125	-100	1014	+ 7.5	W	28	10.9	3.4	fair	A
	Duration of episode: 1 day						Reason for demise: Dissipation							
8	09 Dec.*	1000	B	EOF	~25	?	1007	+ 5.1	WNW	25	10.9	5.8	good	A
	09 Dec.*	1930	C	EOF	~25	~0	1008	+ 4.5	WNW	23	10.7	6.2	good	A
	10 Dec.	1330	I	EOF	~30	- 5	1008	- 0.4	WNW	23	10.0	10.4	excellent	A
	11 Dec.	1530	C	EOF	~20	~0	1011	+ 2.0	WNW	20	9.3	7.3	excellent	A
	12 Dec.	1330	C	Solid overcast	~20	+ 50	1018	+ 3.0	NNW	17	8.9	5.9	fair	A

Wind shifting to north. New WX system to So. and No.

Duration of episode: 3 days

Reason for demise: Replacement

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

December 1981

BUOY NO. 6 (Continued)

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	-- Surface Conditions -- Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
10	16 Dec.*	1930	C	EOF	~25	~0	1021	+ 5.9	WNW	11	9.5	3.6	good	A
	17 Dec.*	0130	D	~Clear	150	-125	1025	+ 6.0	WNW	9	9.3	3.3	weak	A
	Duration of episode: 1 day							Reason for demise: Dissipation						
11	19 Dec.	1930	B	Clear	60	- 30	1021	- 0.9	NW	18	8.4	9.3	excellent	A
	20 Dec.*	1330	C	EOF	30	~0	1026	- 2.2	WNW	17	8.6	10.8	excellent	A
	21 Dec.	1330	Rc	Clear	150	- 75	1029	+ 0.3	SW	6	3.4	8.1	good	A - C
	Duration of episode: 2 days							Reason for demise: Dissipation & replacement						
12	30 Dec.	1530	B	EOF	75	~0	1032	+ 3.0	N	15	8.3	5.3	weak	A
	Duration of episode: 1/2 day							Reason for demise: Dissipation & replacement						

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

January 1982 BUOY NO. 1

Case No.	Date(1982)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Surface Conditions Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
13	02 Jan.	1300	B	Small open cells	350	+ 75	1024	+11.8	N	16	18.5	6.7	weak	A
	Duration of episode: 1 day							Reason for demise: Dissipation & replacement						
14	05 Jan.	1300	B	Very thin streets	300	+ 50	1010	+12.8	NW	25	19.1	6.3	weak	B
	Good threshold formation case.													
	Duration of episode: .5 days							Reason for demise: Dissipation & replacement						
15	08 Jan.	1900	B	Streets	250	+100	1020	+ 6.8	N	23	18.7	11.9	weak	B
	? (Missing satellite imagery)													
16	10 Jan.	2300	C	Solid sheet	50	+200	1011	+ 1.4	WNW	30	19.2	17.8	good	B
	11 Jan.	0900	C	Transition C→O cells	60	+160	1013	+ 1.0	WNW	28	18.9	17.9	good	B

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

January 1982

BUOY NO. 1 (Continued)

Case No.	Date(1982)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	-- Surface Conditions -- Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
	11 Jan.	1300	C	Transition C→O cells	50	+250	1013	+ 2.9	W	35	18.8	15.9	good	B - C

? (Missing satellite imagery)

Duration of episode: ? Reason for demise: ?

Case No.	Date(1982)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
17	15 Jan.	1300	C	Streets	100	+120	1010	+ 8.6	W	30	19.0	10.4	good	'A
	15 Jan.	1900	C	~Solid	150	+150	1013	+ 8.0	WNW	30	18.7	10.7	good	A
	16 Jan.	0200	Rc	Broken	150	+100	1018	+ 9.0	WNW	27	19.0	10.0	good	A

Duration of episode: 1.5 days Reason for demise: Replacement

Case No.	Date(1982)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
20	27 Jan.	0200	B	Solid	100	+250	1014	+ 7.4	N	33	18.0	10.6	good	C
	27 Jan.	1300	C	Open cells	50	+300	1024	+ 5.1	N	26	18.1	13.0	good	C
	28 Jan.	0200	D	·Solid	150	+200	1028	+ 7.6	N	11	17.8	10.2	good	C

Duration of episode: 1.5 days Reason for demise: Replacement

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

January 1982

BUOY NO. 3

Case No.	Date(1981)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	Distance CFD Offshore (nmi)	Buoy to forming edge(nmi)	-- Surface Conditions -- Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
13	02 Jan.	1500	B	EOF	130	0	1016	+ 2.6	NW	26	6.7	4.1	good	A
	02 Jan.	2000	Rc	Clear	300	- 75	1018	+ 2.8	NW	26	6.8	4.0	good	A
	Duration of episode: 1 day							Reason for demise: Dissipation & replacement						
15	08 Jan.	1300	B	Streets	75	+ 50	1011	+ 0.3	WNW	21	6.4	6.1	good	B
	08 Jan.	2000	C	Small open cells	25	+100	1013	(-1.0)	WNW	22	6.2	(7.2)	good	B
	? (Missing satellite imagery)													
	Duration of episode: ?							Reason for demise: ?						
16	10 Jan.	2300	C	Solid	50	+100	1002	(-7.0)	WNW	23	6.0	(13.0)	good	B - C
	Duration of episode: ?							Reason for demise: Replacement						
17	15 Jan.	1300	B	Solid	40	+100	990	+ 0.2	WNW	24	5.3	5.1	good	A
	16 Jan.	0200	Rc	Clear	150	- 20	1008	NA	WNW	24	5.5	NA	good	A

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

January 1982

BUOY NO . 3 (Continued)

Case No.	Date(1982)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	-- Surface Conditions -- Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
	16 Jan.	1300	Rc	Clear	150	-150	1016	+ 0.1	W	13	5.4	5.3	good	A
	Duration of episode: 1 day							Reason for demise: Replacement						
18	22 Jan.	1300	C	Streets	50	+150	1031	(-10.0)	NNW	18	4.7	(14.7)	good	C
	23 Jan.	0200	C	Streets	100	+100	1036	NA	N	16	4.6	NA	good	C
	Duration of episode: 1 day							Reason for demise: Replacement						
19	25 Jan.	0600	B	Solid	50	+100	1003	(+ 4.0)	WNW	20	4.5	(0.5)	good	B
	25 Jan.	1800	C	Small open cells	70	+ 50	1009	(+ 2.0)	WNW	22	4.4	(2.4)	good	B
	Duration of episode: 1/2 day							Reason for demise:						
20	26 Jan.	1500	C	Rp edge	?	?	1015	(+ 3.0)	NW	8	4.6	(1.6)	weak	C
	27 Jan.	0200	C	Solid	70	+175	1017	(+ 2.0)	N	17	4.5	(2.5)	excellent	C
	27 Jan.	1500	C	Streets	40	+160	1021	(+ 3.0)	N	18	4.4	(1.4)	excellent	C
	28 Jan.	0200	Rc	Solid	125	+ 75	1026	(+ 3.0)	NNW	13	4.4	(1.4)	excellent	C

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

January 1982

BUOY NO. 3 (Continued)

Case No.	Date(1982)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
	28 Jan.	1100	Rc,Rp	Clear	300	-150	1026	(+3.0)	W	10	4.3	(1.3)	excellent	C
	Duration of episode: 3 1/2 days							Reason for demise: Dissipation & replacement						
	29 Jan.	1300	Clear	Clear	No clouds forming		1021	+ 3.3	W	17	4.4	1.1	----	C
	Good negative case.													
	Duration of episode: ---							Reason for demise: Replacement						

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

January 1982

BUOY NO. 5

Case No.	Date(1982)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	Distance CFD Offshore (nmi)	Buoy to forming edge(nmi)	Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
13	02 Jan.	1500	B	Clear	100	- 40	1013	+ 1.3	NW	35	7.4	6.1	good	A
	02 Jan.	2000	Rc	Clear	150	- 75	1017	+ 0.5	NW	32	7.4	6.9	good	A
	Duration of episode: 1 day							Reason for demise: Dissipation & replacement						
15	08 Jan.	1300	B	Streets	25	+ 75	1011	(+1.0)	WNW	30	6.5	(5.5)	good	B
	08 Jan.	1800	B	Streets	25	+ 75	1010	(-4.0)	NW	28	6.5	(10.5)	good	B
	? (missing satellite imagery)													
	Duration of episode: ?							Reason for demise: ?						
16	10 Jan.	2300	C	Solid	25	+125	1000	(-13.0)	W	27	6.2	(19.2)	good	B
	Duration of episode: ?							Reason for demise: Replacement						
17	15 Jan.	1500	B	Solid	40	+ 40	989	+ 0.1	NW	30	6.3	6.2	good	A
	16 Jan.	0200	Rc	EOF	100	0	1005	(- 4.8)	NW	30	6.3	(11.1)	good	A
	16 Jan.	1300	Rc	EOF	---	--	1014	(- 2.0)	W	12	6.3	(8.3)	good	A
	Duration of episode: 1 day							Reason for demise: Replacement						
18	22 Jan.	1300	C	Streets	25	+ 25	1032	NA	NNW	26	5.5	NA	good	C
	23 Jan.	0200	Rc	Clear	100	- 40	1036	(-11.6)	N	18	5.5	(17.1)	good	C

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

January 1982

BUOY NO. 5 (Continued)

Case No.	Date(1982)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	-- Surface Conditions -- Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
	23 Jan.	0600	Ad & Rp	EOF	75	0	1036	NA	N	15	5.5	NA	good	C
	Duration of episode: 1 day						Reason for demise: Replacement							
19	25 Jan.	0600	B	Solid	70	+ 50	1000	NA	W	25	5.4	NA	good	B
	25 Jan.	1800	C	Streets	70	+ 50	1006	(- 3.0)	W	29	5.5	(8.5)	good	B
	Duration of episode: 1/2 day						Reason for demise:							
20	26 Jan.	1500	C	Streets	50	+ 50	1015	NA	NW	12	5.4	NA	good	C
	27 Jan.	0200	C	EOF	50	+ 25	1019	NA	N	19	5.7	NA	excellent	C
	27 Jan.	1500	C	Solid	40	+ 50	1023	NA	N	25	5.6	NA	excellent	C
	28 Jan.	0200	Rc	Clear	100	- 50	1025	(- 6.4)	NNW	14	5.5	(11.9)	excellent	C
	28 Jan.	1100	Rc,Rp	Clear	300	-150	1024	(- 2.0)	WSW	7	5.5	(7.5)	excellent	C
	Duration of episode: 3 1/2 days						Reason for demise: Dissipation & replacement							
	29 Jan.	1300	Clear	Clear	no clouds forming		1017	+ 3.6	W	27	5.8	(2.2)	----	C
	Good negative case.													
	Duration of episode: ----						Reason for demise: Replacement							

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

January 1982

BUOY NO. 6

Case No.	Date(1982)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	-- Surface Conditions -- Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
13	02 Jan.	1300	B	Clear	150	-100	1028	+ 4.7	N	17	8.3	3.6	weak	A
	Duration of episode: 1 day							Reason for demise: Dissipation & replacement						
14	05 Jan.	1300	B	Clear	275	-250	1019	+ 6.2	W	22	8.5	2.3	weak	B
	Good threshold case													
	Duration of episode: ----							Reason for demise: Dissipation & replacement						
15	08 Jan.	1900	B	---	50	- 25	1023	+ 1.6	NW	14	8.0	6.4	weak	B
	? (missing satellite imagery)													
	Duration of episode: ?							Reason for demise: ?						
16	10 Jan.	2300	C	EOF	50	- 10	1017	NA	WNW	26	7.3	NA	good	B
	11 Jan.	0800	C	Clear	100	- 80	1014	NA	W	23	7.0	NA	good	B
	11 Jan.	1300	C	Clear	50	- 30	1014	NA	W	27	7.1	NA	good	B → C
	? (missing satellite imagery)													
	Duration of episode: ?							Reason for demise: ?						

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

January 1982

BUOY NO. 6 (Continued)

Case No.	Date(1982)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	Surface Conditions: Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
17	15 Jan.	1300	C	Clear	75	- 50	1012	NA	W	23	6.2	NA	good	A
	15 Jan.	1900	C	Clear	150	-130	1015	0.0	W	17	6.1	6.1	good	A
	16 Jan.	0200	Rc	Clear	200	-180	1020	+ 0.7	WNW	9	6.0	5.3	good	A
		Duration of episode: 1.5 days						Reason for demise: Replacement						
20	27 Jan.	0200	B	EOF	60	0	1023	NA	NNW	23	5.5	NA	good	C
	27 Jan.	1300	C	EOF	70	0	1030	NA	N	19	4.7	NA	good	C
	28 Jan.	0200	D	Clear	---	---	1031	NA	ENE	1	5.2	NA	good	C
		Duration of episode: 1.5 days						Reason for demise: Replacement						
	29 Jan.	1800	Clear	Clear	no clouds forming		1031	4.9	N	11	5.2	0.3	---	C
	Good negative case.													
		Duration of episode: ---						Reason for demise: Replacement						

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

February 1982

BUOY NO. 1

Case No.	Date(1982)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	-- Surface Conditions -- Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
21	14 Feb.	0200	B	Transition C → O cells	100	+250	1021	+10.5	NNW	25	20.8	10.3	small weak	A
	14 Feb.	1530	Rc	Closed thin cells	200	+100	1029	+10.5	NW	10	21.0	10.5	extensive but weak	A
	15 Feb.	0600	D	Remnants	---	---	1031	+15.7	WSW	13	20.9	5.2	weak	A
	Duration of episode: 1 day							Reason for demise: Dissipation						
22	20 Feb.	1830	C	Broken streets	125	+150	1011	+11.0	NNW	26	20.7	9.7	extensive weak	,A
	Duration of episode: 1 day							Reason for demise: Replacement						
23	23 Feb.	0200	B	Transition C→O cells	125	+200	1009	+10.4	N	30	20.6	10.2	extensive weak	A
	23 Feb.	1830	Rc	Overcast	250	+100	1017	+11.0	NNW	20	21.1	10.1	extensive good	A
	24 Feb.	1530	D	Clear	---	---	1017	+18.7	WSW	18	21.4	2.7	----	A
	Clouds well dissipated out to buoy 2 and beyond at this time.													
	Duration of episode: 1 day							Reason for demise: Dissipation						
	24 Feb.	1830	B	Broken	150	+200	1023	+ 9.5	N	27	20.6	11.1	extensive	C
	Duration of episode: 1 day							Reason for demise: Replacement						

Table 1 (Cont'd) — Surface data and cloud conditions at each of the buoys for selected times during each of the 25 cases. (See the last page of the table for explanatory notes).

February 1982

BUOY NO. 3

Case No.	Date(1982)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	-- Surface Conditions -- Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
25	27 Feb.	0200	C	Clear in cleft	?	?	1031	0.0	WNW	21	3.7	3.7	limited but good	C

Duration of episode: 2 days

Reason for demise: Replacement

February 1982

BUOY NO. 6

Case No.	Date(1982)	Time(GMT)	Stage of Formation	Cloud Conditions At Buoy	CFD Offshore (nmi)	Distance Buoy to forming edge(nmi)	-- Surface Conditions -- Baro.Press (mb)	Air Temp (°C)	Wind Dir	Wspd (kt)	Sea Surface Temp(°C)	ΔT (°C)	Quality of cloud Formation	Synoptic Driving situation
21	14 Feb.	0200	B	Clear	200	-125	1023	+ 2.7	NW	15	6.1	3.4	small weak	A
	14 Feb.	1530	Rc	Clear	?	?	1028	+ 4.5	SW	13	6.5	2.0	extensive weak	A
	Duration of episode: 1 day						Reason for demise: Dissipation							
22	20 Feb.	1830	C	Clear	100	- 75	1011	+ 5.7	N	14	6.2	0.5	extensive good	A
	Duration of episode: 1 day						Reason for demise: Replacement							
23	23 Feb.	0200	B	Clear	100	- 70	1014	+ 4.7	NW	18	5.4	0.7	extensive weak	A
	23 Feb.	1830	Rc	Clear	150	- 75	1019	+ 4.0	WNW	6	5.5	1.5	extensive good	A
	Duration of episode: 1 day						Reason for demise: Dissipation							

EXPLANATORY NOTES:

a) Stages of formation: B = beginning, C = continuing, Rc = recessing, D = dissipating, Rp = replacement, Ad = advancement or re-advancement of EOF toward shoreline, I = Intensification.

b) Cloud free distance (CFD) offshore is measured along the air trajectory from shore through the buoy in question.

c) Distance along the air trajectory through the buoy from the buoy to the leading edge of the cloud formation (EOF), and given as a positive or negative distance depending on whether the EOF is upwind or downwind from the buoy.

d) Air temperatures in parenthesis ( ) are from ship reports within $\pm$ 2 hours, $\pm 2^{0}$ latitude and $\pm 2^{0}$ longitude. These serve as estimates when actual buoy data are missing. Because of the uncertain accuracy of ship reported temperatures, the corresponding values of (ΔT) are not used in the scatterplots in Fig. 2.

e) Air-sea temperature difference ΔT sensed by the buoy is number of degrees celsius by which the sea surface is warmer than the air at buoy level.

f) Synoptic driving situation:

A = In the southwest quadrant of a wave cyclone recently passed overhead and travelling northeast.

B = A closed, low pressure system moving from Quebec to Newfoundland.

C = An anticyclone or ridge of high pressure centered between Quebec and the mid Atlantic states.

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